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AN EPITAXIAL YIG 10-CHANNEL FILTER BANK

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Summary

The design, construction and performance of an X-band 10-channel filter bank using magnetostatic wave propagation in epitaxial YIG films is described.

Introduction

Multichannel filter banks have important applications both in communications and ECM systems. Compact surface acoustic wave (SAW) devices have been developed for use at UHF,[1] but filter banks operating a microwave frequencies have been restricted to waveguide, strip line and dielectric resonator techniques which become bulky if multipole circuits are necessary. The aim of the work described here was to design, fabricate and test a 10-channel multiplexed filter bank using magnetostatic wave (MSW) techniques.[2]

The performance goals for the filter banks were

Center frequency	9.0 GHz
Number of channels	10
Channel 3 dB bandwidth	50 MHz
Out-of-band rejection	55 dB
50 dB bandwidth	100 MHz
Multiplexed insertion loss	20 dB
Bandpass ripple	1 dB

Device Design

Several techniques suitable for use in a filter bank, based on MSW analog to SAW, can be envisaged. These include use of periodic transducers,[3] reflective arrays,[4] and multistrip couplers.[5] However, none of these techniques was sufficiently highly developed. Instead the filter bank was designed as 10 narrowband delay lines, each fed from a common input transducer but with separate output transducers as shown in Figure 1.

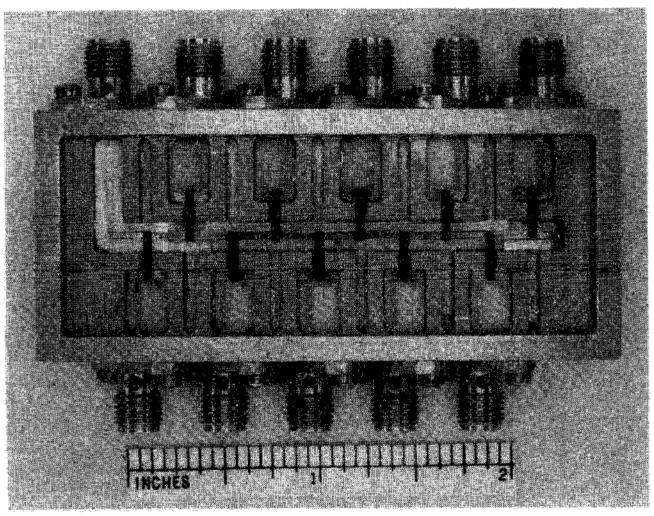

Figure 1. Interior of 10-channel filter bank.

Each delay line consisted of a strip of yttrium iron garnet (YIG) film, 1 mm wide and approximately 20 μm thick, grown by liquid phase epitaxy on a gadolinium gallium garnet (GGG) substrate. A magnetic bias field was applied normal to the YIG film surface, so that magnetostatic forward volume waves could propagate. The delay lines were identical except that there was a gradient in the bias field, so that each delay line experienced a different bias field and hence had a different center frequency. The transducers were formed from 50Ω impedance microstrip line on 0.635 mm thick alumina and were open-circuited at one end. The position of the delay lines along the input transducer was such that each was close to (N−½) electromagnetic half wavelengths from the open circuited end at its center frequency.

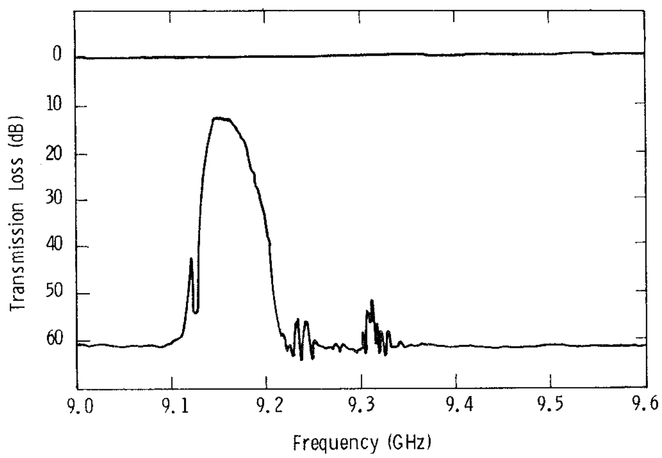

Figure 2. Measured transmission loss as a function of frequency for a single channel.

Narrow bandpass characteristics were obtained by using wide transducers (0.635 mm) spaced 160 μm from the YIG surface. Figure 2 shows the transmission loss, over a 1 cm path length, as a function of frequency measured on an 18.5 μm thick film. In common with other waveguiding systems, YIG films can support higher order modes.[6] The YIG film, from which Figure 2 was obtained, had 18 evaporated aluminum strips, each 264Å thick, positioned with their axes transverse to the YIG strip axis. The resistive aluminum strips preferentially attenuate higher order width modes, i.e. modes with transverse wave numbers $k = 3\pi/W$, $5\pi/W$, etc., where W is the YIG strip width. The YIG film also had reflecting ends and as expected the spacing from the end of the film to the edge of the transducer was critical. It was found that a spacing of 0.31 mm gave a reasonably symmetrical passband shape. The undesired out-of-band responses are approximately 40 dB down on the desired passband in Figure 2.

Results

The assembled device, complete with bias magnet, is shown in Figure 3 and the measured transmission and return loss for all 10 channels as a function of frequency is shown in Figure 4. In these results the out-of-band responses are higher than desired. The nonuniform spacing of the passband center frequencies is due to the nonlinear variation in the bias field along the device length. In addition, variations in the spacing of the ends of the YIG from the transducers resulted in changes in passband shapes. In spite of these shortcomings which are all potentially correctable a general technique for obtaining multichannel filter operation has been demonstrated. In addition it has been shown that a degree of control of the passband shape can be obtained with simple single element microstrip transducers. Further control may be possible with relatively simple multi-element transducers.

Acknowledgment

The work reported was supported in part by the U. S. Air Force Avionics Laboratory under contract No. F33615-77-C-1068.

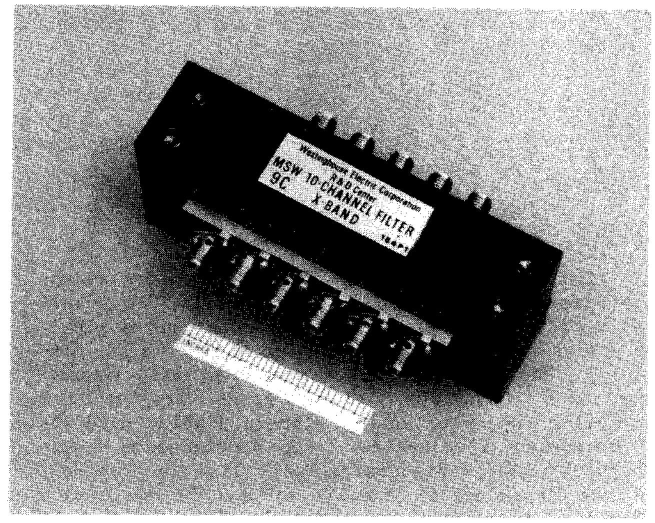

Figure 3. 10-channel filter bank.

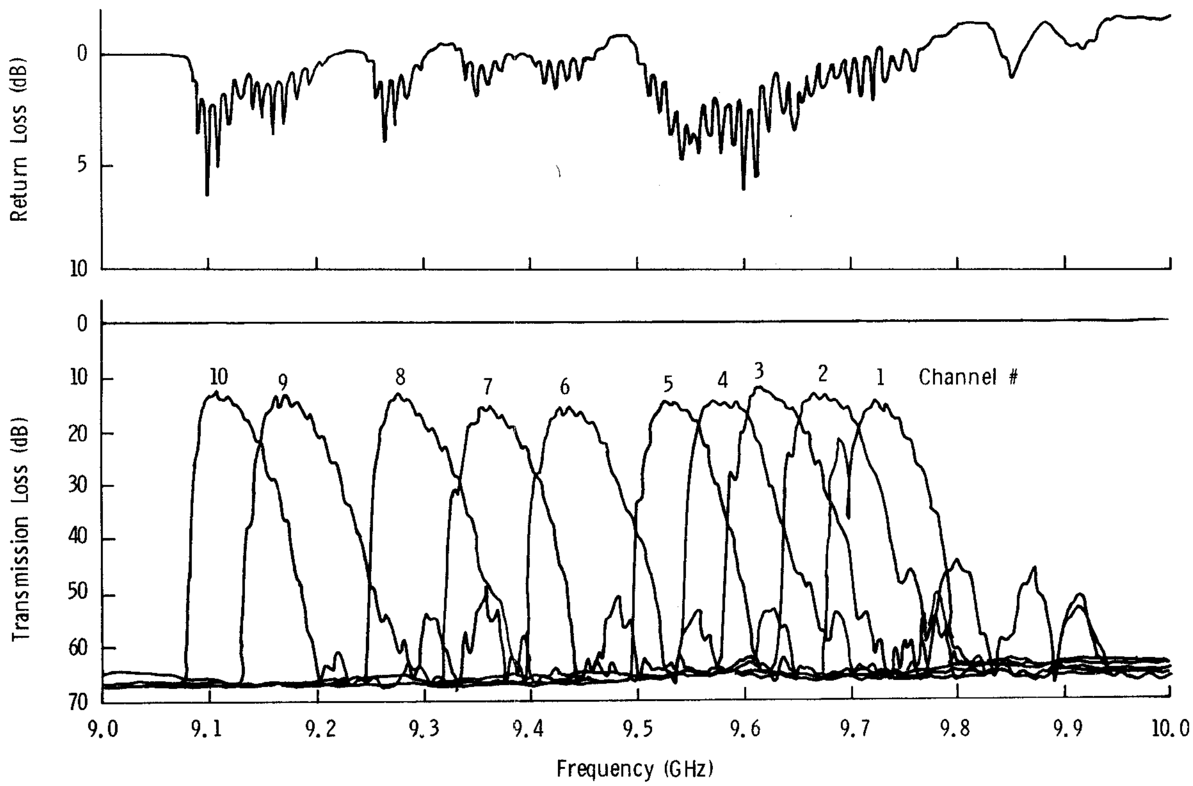

Figure 4. Measured transmission loss and return loss from the input for the 10-channel filter.

References

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